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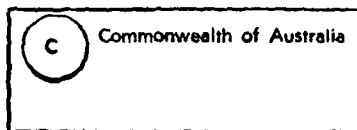
Design of a Flashbulb Firing Unit for Use with High Speed Cameras

K.J. Lee

MRL Technical Note
MRL-TN-594

Abstract

Details of the design and construction of a three channel, multiple flashbulb firing unit are reported here. The unit is adaptable to a variety of high speed camera instrumentation configurations. It can be triggered by a 90 V pulse or by the application of a short circuit and is capable of initiating up to 30 PF300 flashbulbs.



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Design of a Flashbulb Firing Unit for Use with High Speed Cameras

1. Introduction

High speed cinematography places demands on available continuous lighting sources which cannot always be met. In such circumstances flash lighting is used to provide a much higher intensity light source, albeit for a shorter time, than that from continuous incandescent light sources. Electronic flash sources can be used but their duration is generally too short for many applications in the field of explosives and ammunition. Flashbulbs however provide suitable intensity and duration to satisfy many applications in terminal ballistics and explosive technology studies. Because of the blast and fragment hazards associated with field equipment involving explosives and munitions, large, high power, heavy or delicate light sources requiring protection, become a liability. Alternatively, compact, disposable flashbulbs can be placed close to an event and, although ultimately destroyed by blast or fragments, still perform their function. As a result flashbulbs are used for a variety of tasks requiring high speed photography of explosives related events. To perform this function flash bulbs require a rugged, compact, multi-channel unit capable of firing over cable lengths of up to 200 m which is compatible with high speed camera systems. This report describes the design, construction and successful testing of a flashbulb firing unit that meets these requirements. The flashbulb firing unit has survived transportation by road, air and sea and has been used at diverse locations such as Woomera (SA), Graytown (Vic.) and Townsville (Qld). The wide range of climatic conditions encountered by the unit at these locations, including dust, heat and high humidity have had no detrimental effects on its operation or reliability.

2. Flashbulb Firing Unit

2.1 General Description

The flashbulb firing unit, shown in Figures 1 and 2, consists of three independent channels each able to fire up to 10 PF300 flashbulbs wired in series with one ohm by-pass resistors connected across each bulb (Figure 3). For rugged construction light emitting diode bar graph displays were used instead of meters with sensitive moving coil movements to monitor capacitor charging voltage. The circuit diagram of the display section is shown in Figure 4.

Each channel of the flashbulb firing unit can be triggered remotely by a 90 V pulse, a short circuit or by a push-button located on the front panel. The 90 V pulse mode was required for compatibility with existing exploding bridgewire detonator firing/trigger units. Short circuit operation is required when the flashbulb firing unit is triggered directly by high speed cameras such as the Hycam. Such cameras produce a closing switch contact output when a predetermined point on the film is reached, typically the 20 m position on a 30 m roll of 16 mm film.

2.2 Circuit Description

The main circuit diagram of the flashbulb firing unit is shown in Figure 5 and consists of three identical channels. The main dump capacitor C2 is charged via resistor R1 and clamped by diodes D1 and D2 to 200 V DC. A fraction of this charge voltage is applied to the bar graph circuit for capacitor charge indication. The thyristor Q1 is controlled by a 1:1 three winding pulse transformer L1. Secondary winding L1b is clamped by D4 to protect the thyristor cathode gate circuit. Winding L1c couples the 90 V input pulse to the thyristor via a voltage divider consisting of R6 and R7. L1a triggers Q1 in the remote short circuit and direct bush button modes. Capacitor C1 is charged via R4, C3 blocks this DC voltage from the short circuit input. When pressed, the push button switch (or remote short circuit) forms the discharge path (through L1a and C3) for C1 providing the trigger pulse for Q1. Resistor R2 provides a discharge path for Q1 if no load is connected.

The pulse and short circuit inputs use isolated BNC connectors. These connectors provide isolation from ground and between channels avoiding ground loop problems when separate AC generators are used in the field to power equipment connected to the flashbulb firing unit.

2.3 Mechanical Construction

To facilitate field servicing the circuit is chassis mounted to the front panel. The front panel assembly is easily removed from its cabinet by four screws. The power transformers are mounted in the cabinet and connected by a strip plug/socket; this can be seen in the internal layout of the unit in Figure 2.

This arrangement allows all the circuitry to be detached from the transformers and removed. The LED bar graph display is used for its ruggedness and ease of reading (Figure 1). The exact capacitor charging voltage indicated by the LED bar graph is not important, but merely an indication of the charging level. The colour of the LED display changes from yellow to red when the flashbulb firing unit is ready for use.

2.4 Operation

In order to understand the operation of the flashbulb firing unit in a high speed filming system, a summary of the workings of a high speed camera is necessary. A high speed motion picture camera, such as the Hycam, is used to film events on a millisecond time scale. The event is filmed with the film moving through the camera at a high framing rate, so that the event will be recorded progressively, over a number of frames. When the film is viewed at normal projection speed (24 pictures per second), the image movement is slowed allowing detailed study of the event. At a framing rate of 9000 frames per second, the camera will accelerate a 30 m roll of 16 mm film through the camera in less than a second. The event has to be timed to occur when the camera has reached a suitable framing rate, but not too close to the end of the film where it may be lost by film shredding or fogging. The amount of film lost at the end can be 3 m, therefore the camera is usually set to trigger the event around the 22 m position. The camera has a pivoted arm, the free end of which contacts the film roll. In operation this arm follows the film on the feed spool sensing the decreasing diameter of the film. When the previously set film footage has transferred from feed to take-up spool the event switch closure occurs. This event switch closure can be adjusted to occur at any position on the film.

The short running time of the high speed camera (0.9 s for 30 m of film at maximum framing rate) makes manual synchronization impossible and so the camera event switch is used to directly control flash lighting synchronization and firing the event. Figure 6 depicts a typical instrumentation set-up involving a flashbulb firing unit, a high speed camera, a detonator firing unit and a delayed pulse generator (DPG). The MRL designed DPG provides an adjustable time delayed 90 V pulse output when triggered by a 90 V pulse or a short circuit input. It comprises three output channels, one non delayed (t_0) output and two delayed channels. The delayed channels have a selectable delay from 0 to 1 s, in increments of 1 μ s, or 0 to 100 s, in increments of 1 ms, depending on range setting. By using the DPG, triggering of the event and flashbulbs can be independently set to ensure their synchronization, after taking into account the build-up times of the event and the flashbulbs. As the build-up time of an explosive event is usually short compared with that of flashbulb, the event normally needs to be delayed until the flashbulbs attain sufficient intensity.

Figure 7 shows a simple system without a DPG, which can be used for applications where critical synchronization is not required. The event output from the camera is connected to both the flashbulb firing unit and the detonator firing unit. In this case, when the previously set point on the film is reached,

closure of the event switch causes the detonator firing unit and flashbulb unit to be triggered simultaneously.

The flashbulb firing unit has been designed for ruggedness and ease of field servicing. The press button switches used are a sealed microswitch type to prevent dust ingress. The unit can be used rack mounted or free standing but for field use it is normally rack mounted with associated instrumentation in a mobile instrumentation van. No problems have been encountered with the first two flashbulb firing units after hundreds of firings both in the laboratory and in the field.

3. Summary

A flashbulb firing unit has been designed and constructed. Testing in the laboratory and field over a period of several years has shown it to be reliable and rugged.

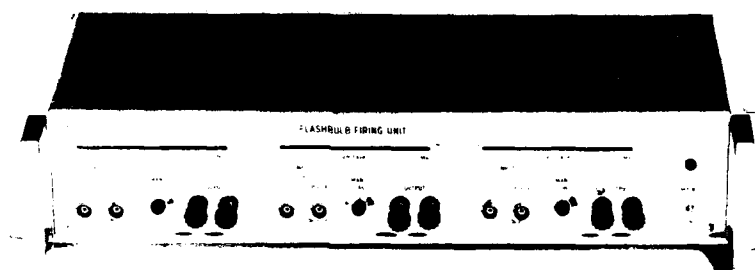


Figure 1: Front panel view showing LED bar graph display.



Figure 2: Internal layout of flashbulb firer.

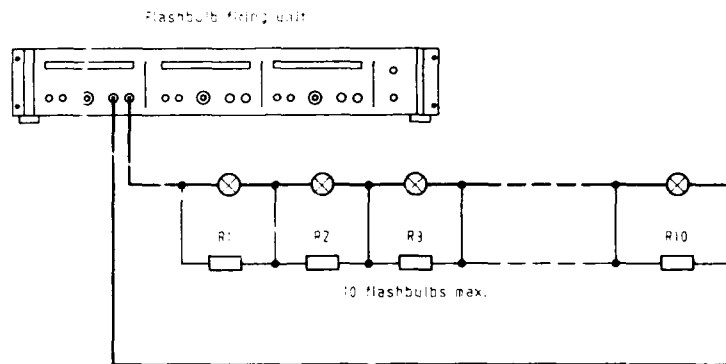


Figure 3: Multi flashbulb system.

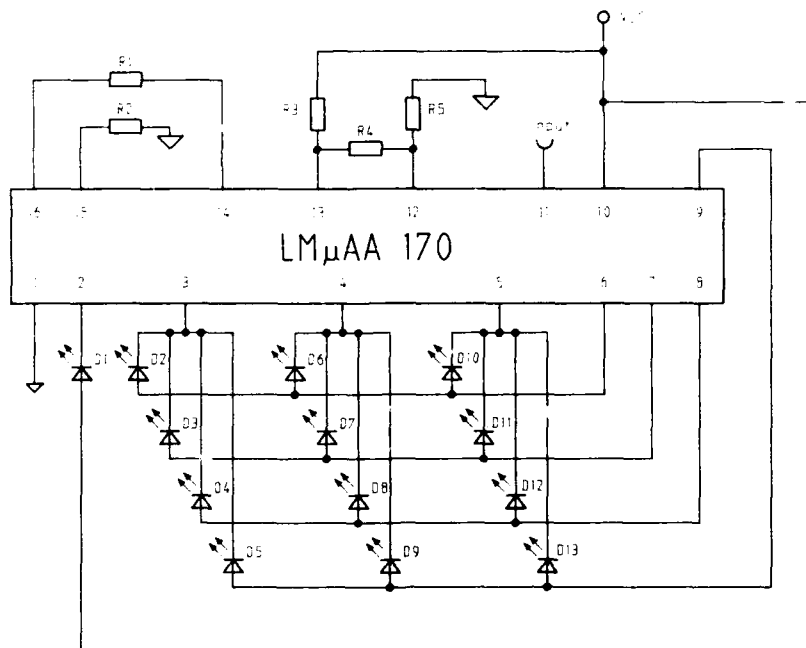


Figure 4: Bar graph display circuit diagram.

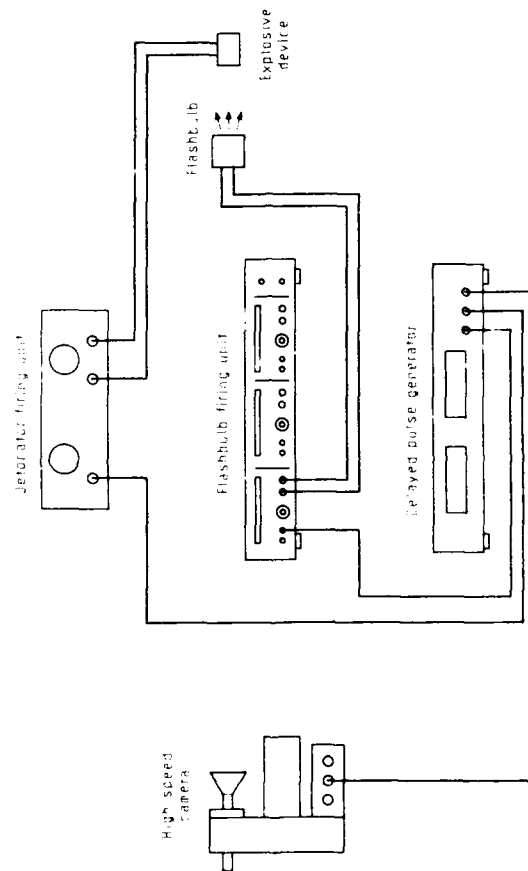


Figure 6: Flashbulb firing unit in pulse initiated system.

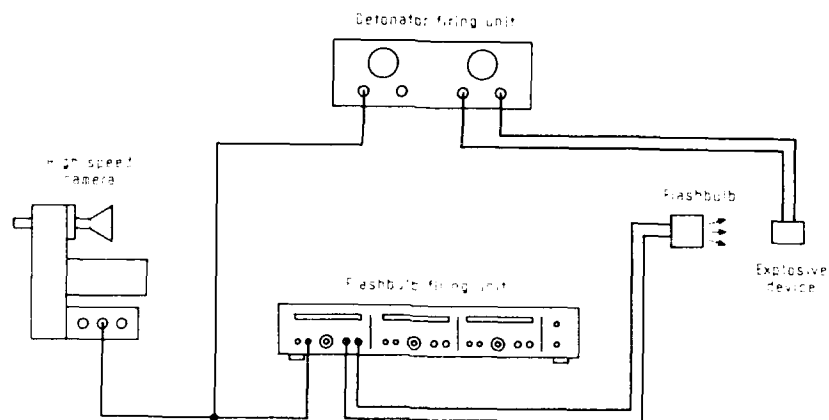


Figure 7: Flashbulb firing unit in short circuit initiated system.

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